PAUL G. ALLEN SCHOOL
OF COMPUTER SCIENCE & ENGINEERING

CSE341: Programming Languages

Lecture 1
Course Mechanics
ML Variable Bindings

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Spring 2019

Welcome!

We have 10 weeks to learn *the fundamental concepts* of programming languages

With hard work, patience, and an open mind, this course makes you a much better programmer

- Even in languages we won't use
- Learn the core ideas around which *every* language is built, despite countless surface-level differences and variations
- *Poor* course summary: "Uses ML, Racket, and Ruby"

Today's class:

- Course mechanics
- *[A rain-check on motivation]*
- Dive into ML: Homework 1 due Wednesday of next week

Concise to-do list

In the next 24-48 hours:

1. Read course web page: http://courses.cs.washington.edu/courses/cse341/19sp/
2. Read all course policies (4 short documents on web page)
3. Adjust class email-list settings as necessary
4. Complete Homework 0 (survey worth 0 points)

5. Get set up using Emacs [optional; recommended] and ML
   - Installation/configuration/use instructions on web page
   - Essential; non-intellectual
     - No reason to delay!

Who: Course Staff

Dan Grossman: Faculty, 341 my favorite course / area of expertise

Seven (!!) *great* TAs

Get to know us!

Staying in touch

- Course email list: **cse341a_sp19@u.washington.edu**
  - Students and staff already subscribed
  - You must get announcements sent there
  - Fairly low traffic
- Course staff: **cse341-staff@cs.washington.edu**
  plus individual emails
- Message Board
  - For appropriate discussions; TAs will monitor
  - Optional/encouraged, won't use for important announcements
- Anonymous feedback link on webpage
  - For good and bad: If you don't tell me, I don't know

Lecture: Dan

- Slides, code, and reading notes / videos posted
  - May be revised after class
  - *Take notes*: materials may not describe everything
    - Slides in particular are *visual aids* for me to use
- Ask questions, focus on key ideas
- Engage actively
  - Arrive *punctually* (beginning matters most!) and well-rested
    - Just like you will for the midterm!
  - *Write* down ideas and code as we go
  - If attending and paying attention is a poor use of your time, one of us is doing something wrong

Section

- Required: will usually cover new material
- Sometimes more language or environment details
- Sometimes main ideas needed for homework
- *Will* meet this week: using Emacs and ML

Material often also covered in reading notes / videos

Reading Notes and Videos

- Posted for each “course unit”
  - Go over most (all?) of the material (and some extra stuff?)

- So why come to class?
  - Materials let us make class-time much more useful and interactive
    - Answer questions without being rushed because *occasionally* “didn’t get to X; read/watch about it”
    - Can point to optional topics/videos
    - Can try different things in class, not just recite things

- Don’t need other textbooks – I’ve roughly made one myself

Office hours

- Regular hours and locations on course web
  - Changes as necessary announced on email list

- Use them
  - *Please visit me*
  - Ideally not *just* for homework questions (but that's good too)

Homework

- Seven total
- To be done individually
- Doing the homework involves:
  1. Understanding the concepts being addressed
  2. Writing code demonstrating understanding of the concepts
  3. Testing your code to ensure you understand and have correct programs
  4. “Playing around” with variations, incorrect answers, etc.

  Only (2) is graded, but focusing on (2) makes homework harder
- Challenge problems: Low points/difficulty ratio

Note my writing style

- Homeworks tend to be worded very precisely and concisely
  - I write like a computer scientist (a good thing!)
  - Technical issues deserve precise technical writing
  - Conciseness values your time as a reader
  - You should try to be precise too
- *Skimming or not understanding why a word or phrase was chosen can make the homework harder*
- By all means ask if a problem is confusing
  - Being confused is normal and understandable
  - And I may have made a mistake

Academic Integrity

- Read the course policy carefully
  - Clearly explains how you can and cannot get/provide help on homework and projects
- Always explain any unconventional action
- I have promoted and enforced academic integrity since I was a freshman
  - Great trust with little sympathy for violations
  - Honest work is the most important feature of a university
- This course especially: Do not web-search for homework solutions! We will check!

Exams

- Midterm: Friday May 3, in class
- Final: Thursday June 13, 8:30-10:20AM
- Same concepts, but different format from homework
  - More conceptual (but write code too)
  - Will post old exams
  - Closed book/notes, but you bring one sheet with whatever you want on it

Coursera (more info in document)

- I've taught this material to thousands of people around the world
  - A lot of work and extremely rewarding
- You are not allowed to participate in that class!
- This should have little impact on you
  - Two courses are separate
  - 341 is a great class and staff is committed to this offering being the best ever
- But this is a neat thing you are likely curious about…

More Coursera

- Why did I do a MOOC?
  - Have more impact (like a textbook) for my favorite stuff!
  - Experiment with where higher-ed might be going

- So why pay tuition?
  - Personal attention from humans
  - Homeworks/exams with open-ended questions
  - Class will adjust as needed
  - We can be sure you actually learned
  - Course is part of a coherent curriculum
  - Beyond the classroom: job fairs, advisors, social, …

Has Coursera help/hurt 341?

- Biggest risks
  - Becomes easier to cheat – don't! (And I've changed things)
  - I become too resistant to change – hope not!

- Benefits too
  - More resources: videos, grading scripts, …
  - Way fewer typos
  - Taking the "VIP version" of a more well-known course
  - Change the world to be more 341-friendly

Questions?

Anything I forgot about course mechanics before we discuss, you know, programming languages?

What this course is about

- Many essential concepts relevant in any programming language
  - And how these pieces fit together
- Use ML, Racket, and Ruby languages:
  - They let many of the concepts “shine”
  - Using multiple languages shows how the same concept can “look different” or actually be slightly different
  - In many ways simpler than Java
- Big focus on *functional programming*
  - Not using *mutation* (assignment statements) (!)
  - Using *first-class functions* (can’t explain that yet)
  - But many other topics too

Why learn this?

This is the “normal” place for course motivation

- Why learn this material?

But we don’t have enough shared vocabulary/experience yet

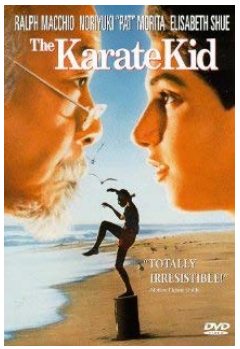
- So 3-4 week delay on motivation for functional programming
- I promise full motivation: delay is worth it
- (Will motivate immutable data at end of “Unit 1”)

My claim

Learning to think about software in this "PL" way will make you a better programmer even if/when you go back to old ways

It will also give you the mental tools and experience you need for a lifetime of confidently picking up new languages and ideas

[Somewhat in the style of *The Karate Kid* movies (1984, 2010)]



A strange environment

- Next 4-5 weeks will use
  - ML language
  - Emacs editor
  - Read-eval-print-loop (REPL) for evaluating programs
- Need to get things installed and configured
  - Either in the Allen School labs or your own machine
  - We've written thorough instructions (questions welcome)
- Only then can you focus on the content of Homework 1
- Working in strange environments is a CSE life skill

Mindset

- "Let go" of all programming languages you already know

- For now, treat ML as a "totally new thing"
  - Time later to compare/contrast to what you know
  - For now, "oh that seems kind of like this thing in [Java]" will confuse you, slow you down, and you will learn less

- Start from a blank file…

A very simple ML program

[The same program we just wrote in Emacs; here for convenience if reviewing the slides]

```
(* My first ML program *)

val x = 34;

val y = 17;

val z = (x + y) + (y + 2);

val q = z + 1;

val abs_of_z = if z < 0 then 0 - z else z;

val abs_of_z_simpler = abs z
```

A variable binding

```
val z = (x + y) + (y + 2); (* comment *)
```

More generally:

```
val x = e;
```

- *Syntax*:
  - *Keyword* **`val`** and *punctuation* **`=`** and **`;`**
  - *Variable* ***`x`***
  - *Expression* ***`e`***
    - Many forms of these, most containing *subexpressions*

The semantics

- Syntax is just how you write something

- Semantics is what that something means
  - Type-checking (before program runs)
  - Evaluation (as program runs)

- For variable bindings:
  - Type-check expression and extend static environment
  - Evaluate expression and extend dynamic environment

So what is the precise syntax, type-checking rules, and evaluation rules for various expressions? Good question!

ML, carefully, so far

- A program is a sequence of *bindings*
- *Type-check* each binding in order using the *static environment* produced by the previous bindings
- *Evaluate* each binding in order using the *dynamic environment* produced by the previous bindings
  - Dynamic environment holds *values*, the results of evaluating expressions
- So far, the only kind of binding is a *variable binding*
  - More soon

Expressions

- We have seen many kinds of expressions:

  `34` **`true`** **`false`** **`x`** ***`e1+e2`*** ***`e1<e2`***

  `if` ***`e1`*** **`then`** ***`e2`*** **`else`** ***`e3`***

- Can get arbitrarily large since any subexpression can contain subsubexpressions, etc.

- Every kind of expression has
  1. Syntax
  2. Type-checking rules
     - Produces a type or fails (with a bad error message ☹)
     - Types so far: **`int`** **`bool`** **`unit`**
  3. Evaluation rules (used only on things that type-check)
     - Produces a value (or exception or infinite-loop)

Variables

- Syntax:

  sequence of letters, digits, _, not starting with digit

- Type-checking:

  Look up type in current static environment

  – If not there fail

- Evaluation:

  Look up value in current dynamic environment

Addition

- Syntax:

  e1 **+** ***e2*** where ***e1*** and ***e2*** are expressions

- Type-checking:

  If ***e1*** and ***e2*** have type **`int`**,

  then ***e1*** **+** ***e2*** has type **`int`**

- Evaluation:

  If ***e1*** evaluates to **`v1`** and ***e2*** evaluates to **`v2`**,

  then ***e1*** **+** ***e2*** evaluates to sum of **`v1`** and **`v2`**

Values

- All values are expressions
- Not all expressions are values
- A value “evaluates to itself” in “zero steps”
- Examples:
  - **`34`**, **`17`**, **`42`** have type **`int`**
  - **`true`**, **`false`** have type **`bool`**
  - **`()`** has type **`unit`**

Slightly tougher ones

What are the syntax, typing rules, and evaluation rules for conditional expressions?

What are the syntax, typing rules, and evaluation rules for less-than expressions?

The foundation we need

We have many more types, expression forms, and binding forms to learn before we can write “anything interesting”

Syntax, typing rules, evaluation rules will guide us the whole way!

For Homework 1: functions, pairs, conditionals, lists, options, and local bindings

- Earlier problems require less

Will not add (or need):

- Mutation (a.k.a. assignment): use new bindings instead
- Statements: everything is an expression
- Loops: use recursion instead